RHIC RUN 3 (FY2003) Running Projections
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This note discusses possible operation modes for the RHIC FY2003 running period including constraints from cryogenic cool-down, machine set-up and beam commissioning.

After the summer shut-down both RHIC rings are at room temperature and many areas have been brought to atmospheric pressure. A full 4 weeks will be required to cool down to 4 Kelvin. By the end of the run the new Helium storage system and the Liquid Nitrogen pre-cooler will be available. In this case only one week of refrigerator operation is required for the ring warm-up to 80 Kelvin.

A number of RHIC running modes are considered in RHIC, such as Au-Au collisions, polarized proton collision, deuteron on Au collisions, etc. At this year's RHIC retreat it was agreed that for each mode we should plan for 2 weeks of machine set-up with the goal to establish collisions and a 3-week machine development period ("ramp-up") with the goal of reaching a "final" luminosity for the subsequent data taking period. During this ramp-up period detector set-up can occur, however with priority for machine development. No significant machine development would by scheduled during the data taking period.

For example, the expected 29 weeks of RHIC refrigerator operation during FY2003 would be scheduled in the following way for two RHIC operating modes:

Cool-down:	4 weeks
Set-up mode 1	2 weeks
Ramp-up mode 1	3 weeks
Data taking mode 1	7 weeks
Set-up mode 2	2 weeks
Ramp-up mode 2	3 weeks
Data taking mode 2	7 weeks
Warm-up	1 week

For 3 modes of equal length the data taking period would be 3 weeks per mode.

Table 1 shows the luminosities achieved at the end of the RUN 2 (FY2001/02) for Au-Au and proton-proton collisions. The average store luminosity was for a store with no hardware problems and with a luminosity that agreed well with predicted values from intensity and beam emittance (store # 1812 for Au-Au, store # 2304 for p-p). The integrated weekly luminosity is the average over the last few weeks during which the luminosity was fairly constant. The ratio of average weekly luminosity over store luminosity was 27% and 42% for Au-Au and p-p, respectively. Note that this includes all interruptions such as maintenance, studies, etc.

Mode	# bunches	Ions/bunch [$\times 10^9$]	β* [m]	Emittance [$\pi\mu$m]	L_{peak} [$cm^{-2}s^{-1}$]	L_{ave}(store) [$cm^{-2}s^{-1}$]	L_{ave} (week) [$week^{-1}$]
Au-Au	55	0.6	1	15-40	3.7×10^{26}	1.5×10^{26}	24 $(\mu b)^{-1}$
(p↑-p↑)	55	70	3	25	1.8×10^{30}	1.2×10^{30}	0.3 $(pb)^{-1}$

Table 1: Achieved beam parameters and luminosities for the RHIC RUN 2 (FY2001/02)

Table 2 lists the expected maximum peak and average luminosities for the possible modes in FY2003 that could be achieved by the end of the 3-week ramp-up period. For all modes it was assumed that the beam energy is 100 GeV/nucleon. The average store luminosity is for a "good" store as defined above. This is a number predictable from the beam parameters. The weekly integrated luminosity was then obtained by using a ratio of 40% between average weekly and average store luminosity based on our experience from p-p running. The expected sigma of the diamond length is 20 cm due to the availability of the full voltage from the 200 MHz storage cavities. Note that beta-star of 1 m is only available at PHENIX and STAR. PHOBOS and BRAHMS are limited to 2m.

Mode	# bunches	Ions/bunch [$\times 10^9$]	β* [m]	Emittance [$\pi\mu$m]	L_{peak} [$cm^{-2}s^{-1}$]	L_{ave}(store) [$cm^{-2}s^{-1}$]	L_{ave} (week) [$week^{-1}$]
Au-Au	56	1	1	15-40	14×10^{26}	3×10^{26}	70 $(\mu b)^{-1}$
(p↑-p↑)	112	100	1	25	16×10^{30}	10×10^{30}	2.8$(pb)^{-1}$
d-Au	56	80(d), 1(Au)	2	20	4×10^{28}	1.6×10^{28}	4 $(nb)^{-1}$
Si-Si	56	7	1	20	5×10^{28}	2×10^{28}	5 $(nb)^{-1}$

Table 2: Maximum luminosities that can be reached after 3 week ramp-up period.

Finally, Table 3 shows the expected integrated luminosities per week and total integrated luminosity for a run with 2 modes (7 weeks / mode) and a run with 3 modes (3 weeks / mode) for both last year's luminosities (from Table 1), which represents a minimum expectation, and for the maximum luminosities from Table 2.

Mode	L_{ave} (week) [week^{-1}]	Int. Lumi. 2 modes	Int. Lumi. 3 modes	L_{ave} (week) [week^{-1}]	Int. Lumi. 2 modes	Int. Lumi. 3 modes
	Minimum expectation (from Table 1)			Maximum expectation (from Table 2)		
Au-Au	24(μb)$^{-1}$	168(μb)$^{-1}$	72(μb)$^{-1}$	70 (μb)$^{-1}$	490(μb)$^{-1}$	210(μb)$^{-1}$
(p↑-p↑)	0.3(pb)$^{-1}$	2.1(pb)$^{-1}$	0.9(pb)$^{-1}$	2.8(pb)$^{-1}$	19.6(pb)$^{-1}$	8.4(pb)$^{-1}$
d-Au	?	?	?	4 (nb)$^{-1}$	28 (nb)$^{-1}$	12 (nb)$^{-1}$
Si-Si	?	?	?	5 (nb)$^{-1}$	35 (nb)$^{-1}$	15 (nb)$^{-1}$

Table 3: Expected integrated luminosities during the data taking period for 2 and 3 modes. The first three columns represent the minimum values, the last three columns show the maximum expected.

All the modes listed will require a similar set-up and ramp-up time of a total of about 5 weeks. After a running mode has been established changing the collision energy can be achieved in about 2 weeks (1 week set-up and 1 week ramp-up).

Following are specific comments on the running modes:

<u>d-Au:</u>

d –Au collisions can be set-up with the deuteron beam in either blue or yellow ring. The present preferred option is with deuterons in the blue ring if d-Au is the first mode during the upcoming run. This will allow set-up with deuteron beam to begin earlier since the blue ring is cold a few days before yellow. Switching to deuterons in the yellow ring at a later time should be regarded as going to a different mode with again about 2 weeks of set-up and 3 weeks of ramp-up.

<u>pol. protons-pol. protons:</u>

We expect that the p-p luminosity can be increased significantly since it should be possible to go to beta-star of 1 m with a working betatron tune feedback. During the last run p-p was much less sensitive to intensity related vacuum problems and we therefore expect that operation with 112 bunches should be possible.

The Siemens motor-generator for the AGS will be repaired and give us again the nominal ramp rate. Also, the source polarization has been improved from typically 65-70% to 75%. Based on previous polarized proton operation with the Siemens this should give about 45 % polarization at AGS extraction without any further improvements. With additional improvements, developed during the last run, a polarization of up to 50-55% could be reached. We are installing a fast polarimeter in the AGS which is based on the RHIC polarimeter design. This should significantly improve the reliability of polarization delivery from the AGS.

We are proposing that a RHIC p-p run is scheduled later during the RHIC run so that a 3 week AGS polarized proton commissioning run can be completed before a RHIC p-p run would start. The goal of this commissioning run would be to demonstrate a minimum of 45% polarization at AGS extraction.

A first test of acceleration of polarized protons to 250 GeV in RHIC would be very useful to prepare for future running. With the RHIC tune feedback and a resurveyed machine it is expected that polarization would survive to full energy.

Au-Au:

The main improvement for Au-Au operation will come from improved vacuum bake-out and low field solenoids in the warm sections to suppress intensity related instabilities. We are hoping to reach full design intensity. At the same time we are installing instrumentation to be able to investigate this instability.

Si-Si:

The listing for Si-Si serves as an example of an intermediate heavy ion. Si is easily produced by the injector and with an equal number of protons and neutrons acceleration in RHIC is the same as for deuterons.